Impact Scars at Kilauea[1]

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KILAUEA CALDERA is an ellipsoidal area about two by three miles in extent, whose floor around its eastern, northern, and northwestern margins stands 200 to 500 feet below the surrounding surface of Kilauea volcano. At the southwest the caldera is open at grade and any copious lava flow would pass out and down the south slope of the volcano. The floor of the caldera is a low basaltic shield which at its apex, around Halemaumau, stands more than 200 feet above the lower parts of the northeast margin.

Halemaumau, the so-called firepit, is at present somewhat more than 3,000 feet in diameter, and its floor, at about 450 feet below the rim, consists of the surface of the 1954 lava flow, with a few protruding cone remnants from the more bulky 1952 flow. The floor of the caldera to the north, east, and northeast of Halemaumau consists of pahoehoe lava flows marked by tumuli and other characteristic features. Parts of the area to the west and south show the fresh surface of the 1921 lava flow, but more of the area to the south and west is mantled by ash beds and by thin layers and surface windrows of pumice. Surrounding Halemaumau, which was enlarged greatly by phreatic explosions in 1924, the surface of the caldera floor is strewn with blocks thrown out at that time and ranging up to several feet in diameter. On the eastern side, where the blocks landed on bare lava flows, in many instances the blocks broke through the surface lava layers into blister or other cavities beneath. Some remained in the holes and others ricocheted beyond, commonly showing their origin from the direction of the firepit. On the western side, the ash layers were thicker and offered more cushioning; here there are a few impact craters where blocks fell, but these are not as conspicuous as those of another older series which are to be described in this paper. The limits to which blocks of the 1924 explosive eruption were thrown are easily seen in the field. The holes in the lava are shown in Figure 1.

The caldera margin, from the east side around to the north and west and to the southwest of Halemaumau, is a rock cliff in which the lava flow section is clearly exposed. The southeast and south margin falls in an area where ash layers from successive eruptions amount to 30 or more feet in thickness. Along this line the surface faulting is compound and the ash section shows several parallel cracks with displacement along some. The hard rock margin is exposed in only a few places. To the south and southwest, the margin of the caldera is outlined by a rolling, sand-covered surface, with lava rock a few feet down, but exposed only in gullies that notch the margin.

[1] Publication authorized by U. S. Geological Survey. Manuscript received July 2, 1956.

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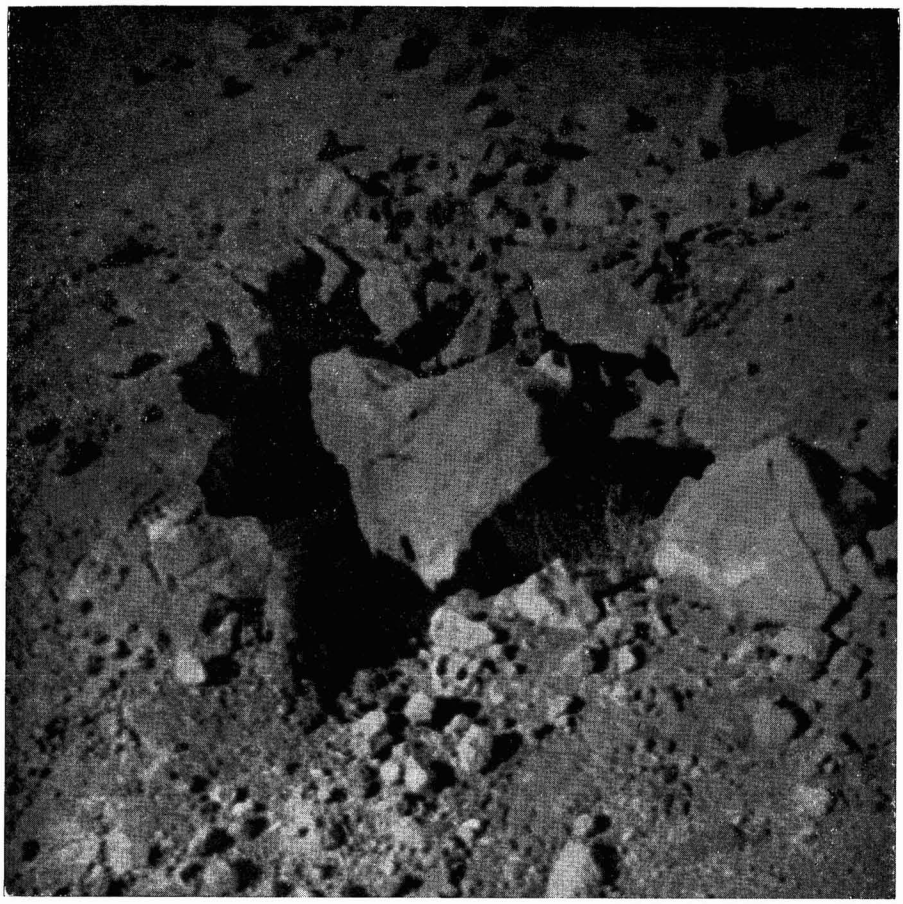

FIG. 1. A hole in the crust of the pahoehoe formed by the block shown, flung from the pit of Halemaumau by phreatic explosion in 1924.

Southeastward from Halemaumau, after passing the area of the 1924 blocks and coming onto the ash terrane between the tourist parking field and Keanakakoi Crater, there is revealed an area marked by numerous circular scars. This area, outlined on Figure 2, is strewn with blocks, ranging to several feet in diameter. It extends across the several linear terraces and crack scars leading up to the smooth upland southwest of Keanakakoi Crater and several hundred feet beyond before the blocks and the circular scars come to an end. An area of the scars runs north of the road, toward the west being practically on the level filled by the Kilauea lavas, then they are found on the higher level to the east and continue to beyond Keanakakoi. The principal area is south of the road, running southward toward the principal rim bluff, here marked by ash. The scars continue beyond the bluff however and are found on the upper sandy plateau to the southward (Fig. 2).

The gritty, block-strewn surface carries a scanty vegetation, consisting of a few small ohia trees (*Metrosideros polymorpha*) 6 or 8 feet high, scattered shrubs of pukeawe (*Styphelia Tameiameiae*), ohelo (*Vaccinium reticulatum*), and kupaoa (*Railliardia* sp.), a few small, isolated ferns, sedges, and grasses, a native *Portulaca* species, and kukae nene (*Coprosma ernodeoides*).

The impact scars are outlined by rings, generally 2 to 12 feet in diameter (Fig. 3). A few are as much as 20 feet across. The rings consist in part of coarser fragments ranging up to 6- or 8-inch blocks and are conspicuous because of the lag effect whereby associated finer material has been blown and washed away. Within each ring is a central depression a few inches to one or two feet deep, with a surface of finer silt which has washed in from the surrounding ring (Fig. 4). In many of the rings the silt of the central depression has a slightly cemented crust due to drying out of capillary moisture, in common with most of the surface of the ash terrane. The general appearance of the rings, where they are closely spaced, resembles polygonboden, but the similarity is certainly superficial and is due to lag processes rather than to frost (Fig. 5).

The larger rings often retain the blocks that apparently caused them, or the block responsible can often be identified with confidence a few feet beyond (Figs. 6 and 7). There is a preponderance of indicated flight directions stemming from the vicinity, roughly, of the present Halemaumau. Some of the blocks have broken on landing, as also have some of those of the 1924 series.

Many of the rings are marked by one or more small trees or shrubs which have taken

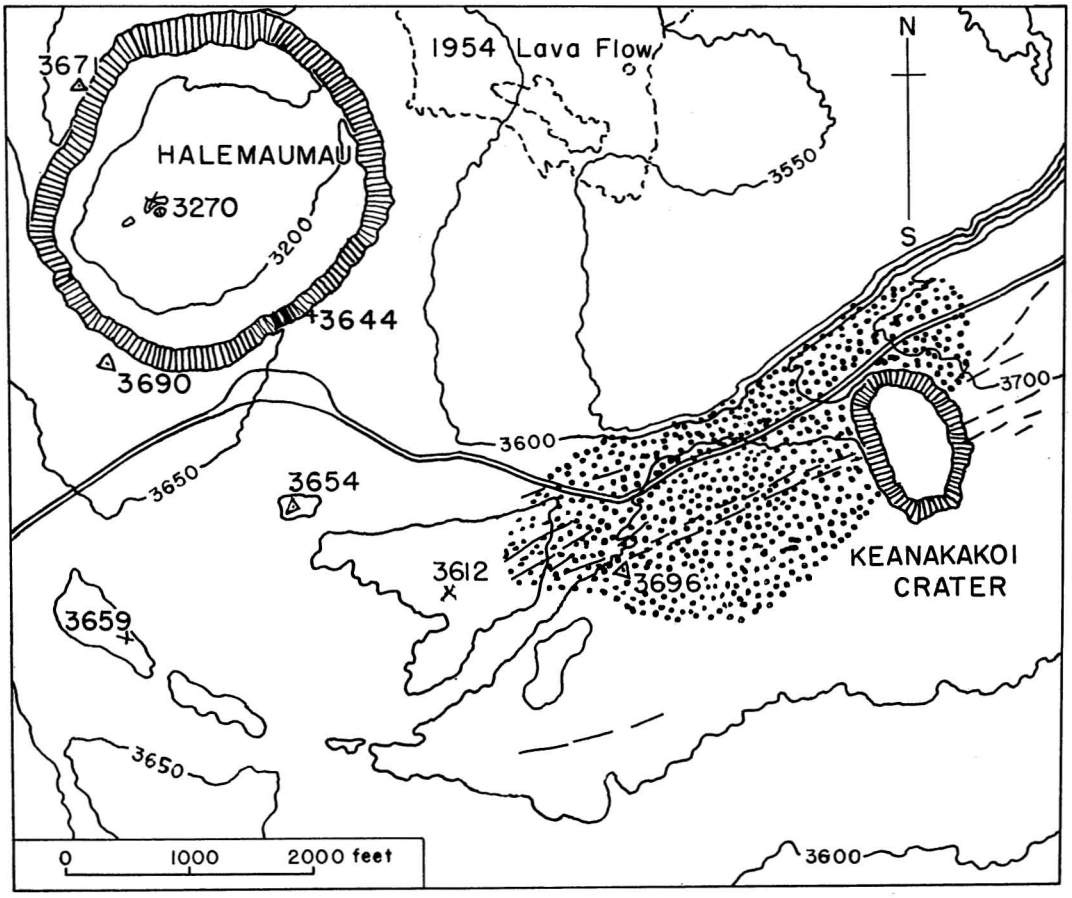

FIG. 2. Sketch map showing the southern part of the caldera of Kileauea and distribution (stippled area) of the impact scars here described.

FIG. 3. Scar with small stone within. Scar about 7 feet across.

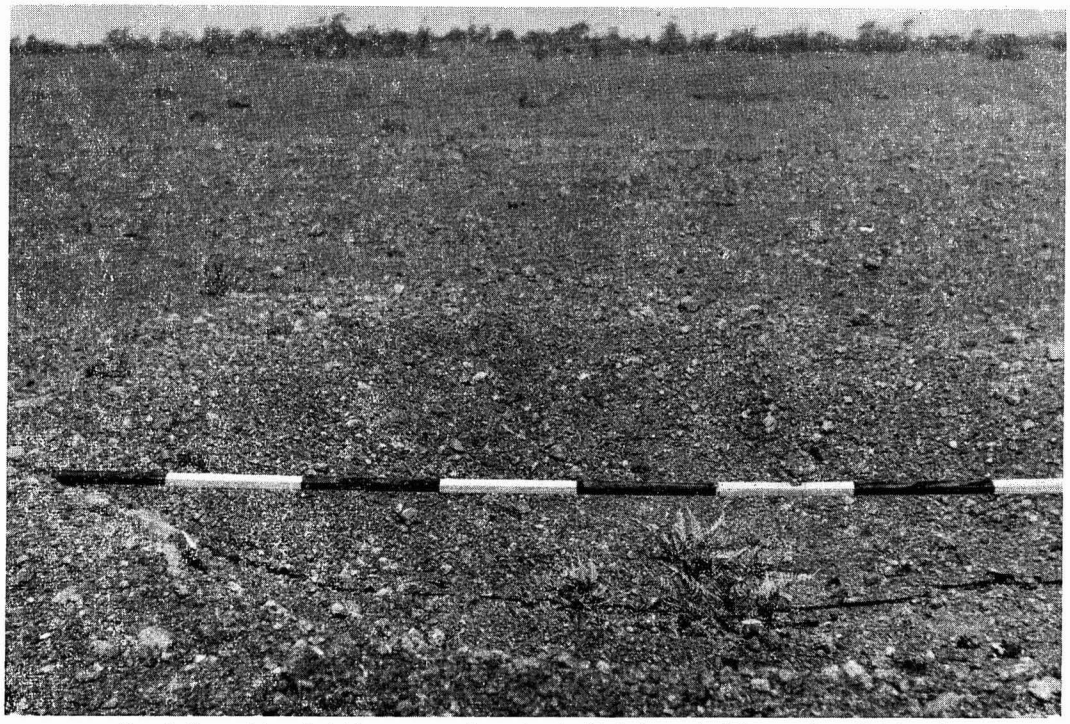

FIG. 4. Scar with pole laid across to show depth. (Pole is marked in one-foot divisions.)

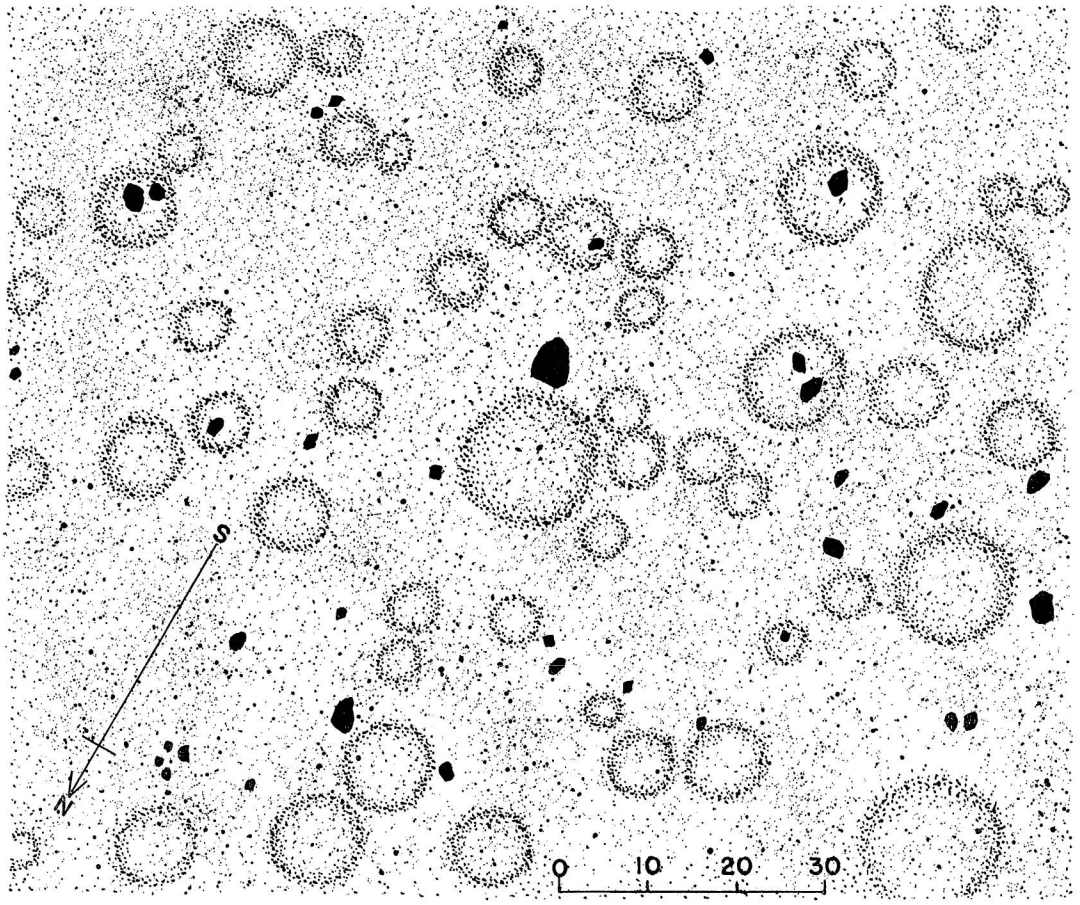

FIG. 5. Pattern of area where the scars are thickest, sketched by rope survey. The large black spots are by actual survey of size and position; smaller pattern of rings is by survey but dots are symbolic.

root in the finer soil of the center portion, or in the shelter of the block which remains. Other vegetation also is somewhat adapted to the ring pattern.

It can reasonably be supposed that this outer series of scars was formed in the 1790 eruption. If they had been formed earlier they would likely have been destroyed by the ash flung out by that eruption. However, there is no contemporary record and we are left with this very general evidence and presumption. That eruption was very violent and threw out much accidental material.

The rims are by no means covered by coarse blocks, and at midday the whole pattern is fairly faint, though discernible by a person who looks for it. At sunrise and in late afternoon the rings are most conspicuous from their relative relief. In the central part of their distribution the rings occur perhaps in every 20-foot square of the ground; around the margin of the area they are scarcer, perhaps two or three in an acre.

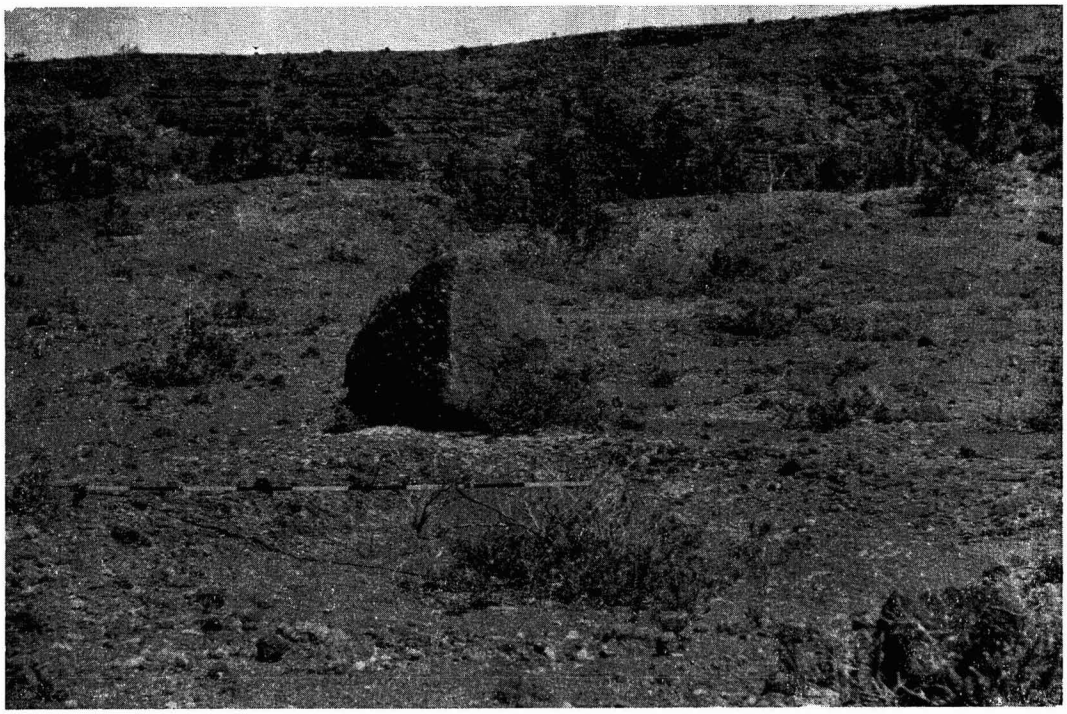

FIG. 6. Ring with pole showing depth and with responsible block beyond.

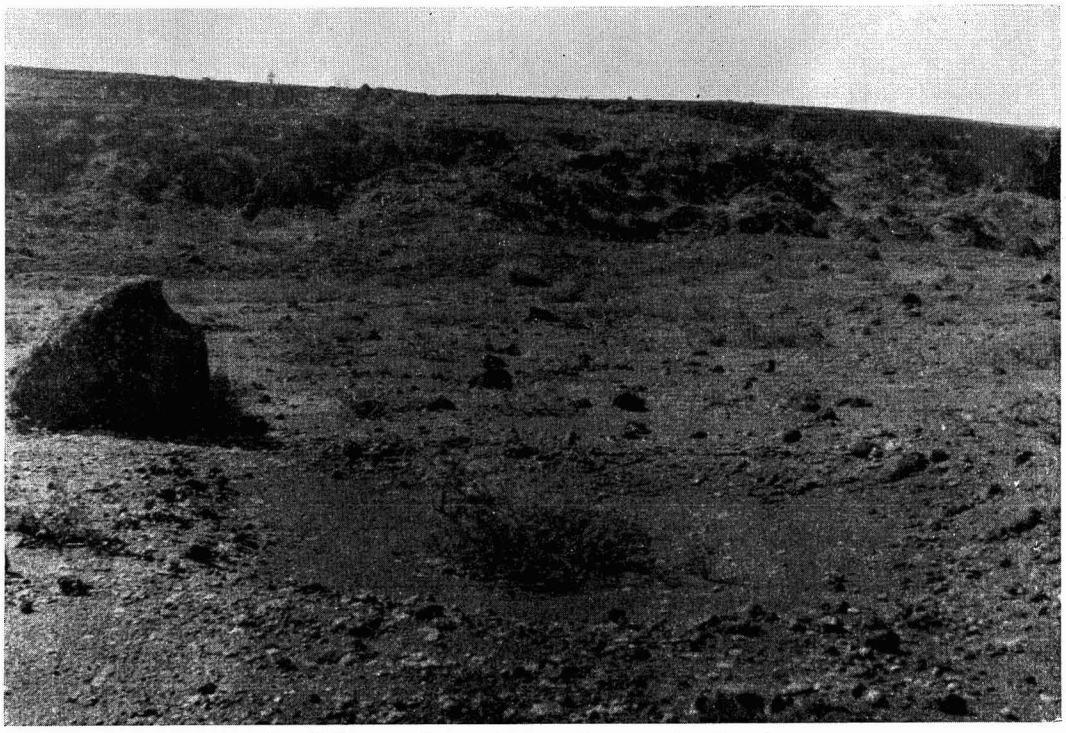

FIG. 7. Same as Figure 6, as seen from another direction.

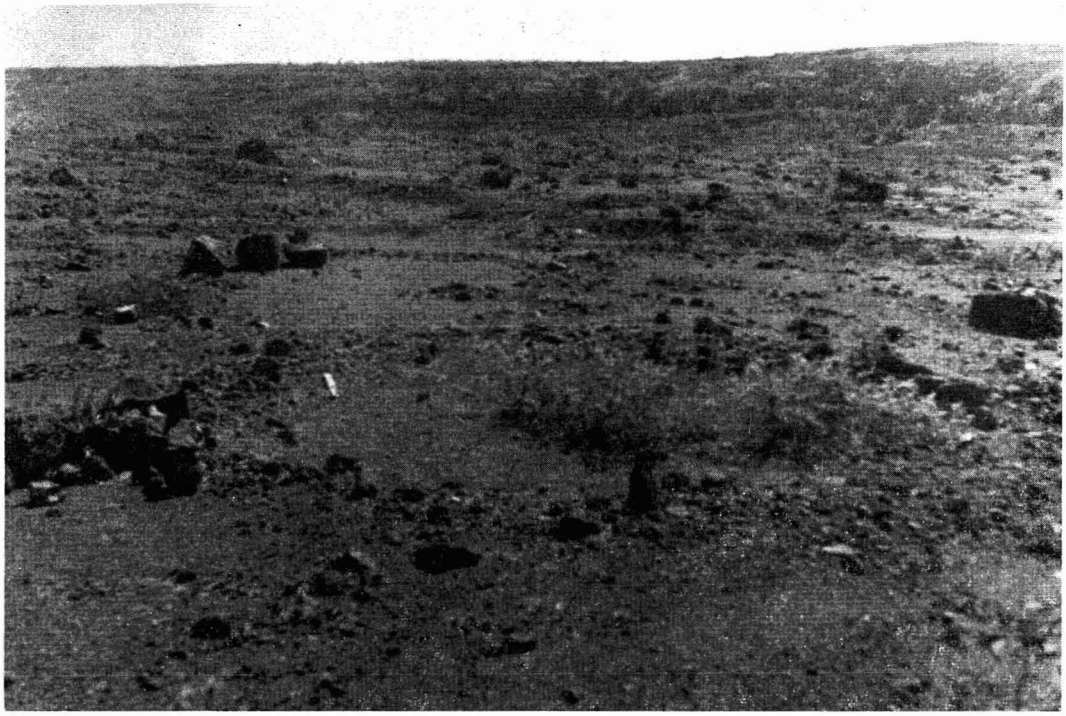

FIG. 8. Several rings can be seen, that in the foreground having vegetation in it and broken stone at the left.

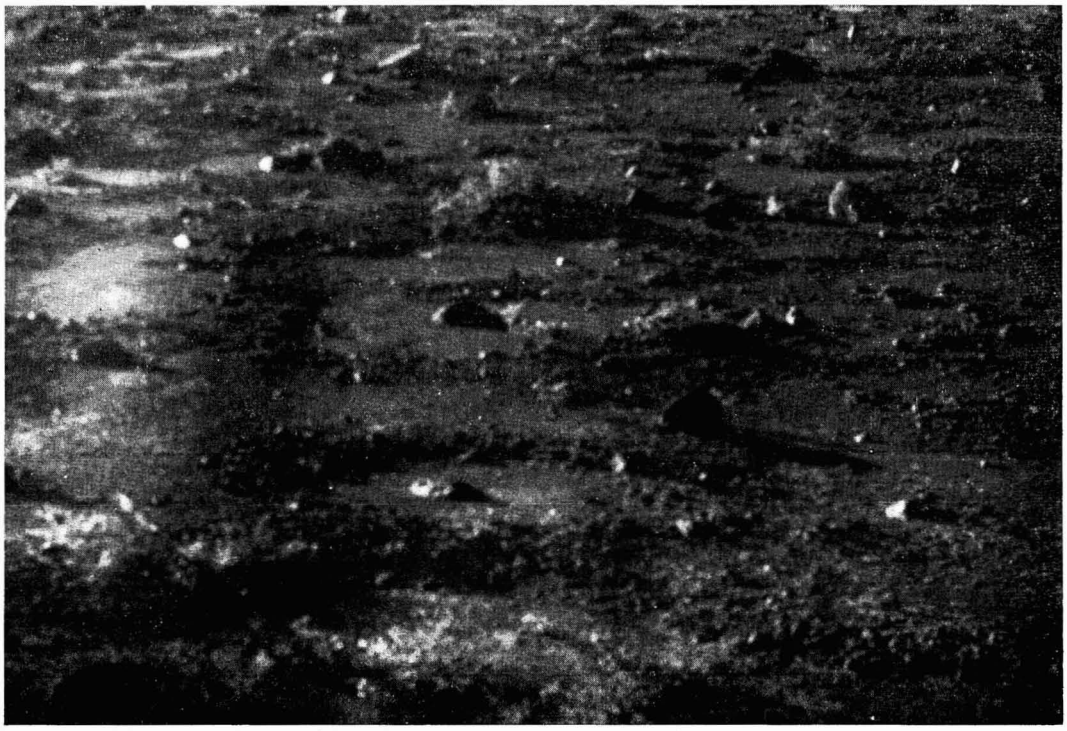

FIG. 9. Pattern of rings with stones on northern side of road near Halemaumau.